UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
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REPLY TO THE ATTENTION OF:
WA-16J

MEMORANDUM

SUBJECT: Vacant Lot Site: Determination of a Clean-Up Goal for Lead

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TO: John O'Grady
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I. Purpose

This memorandum presents soil clean-up goals (CUGs) for lead at the Vacant Lot site. The calculation of the CUG is done under the assumption that exposure will occur under a light industrial/commercial scenario.

II. Background

The Vacant Lot site is a former parking lot located in the City of North Chicago, Lake County, Illinois, which reportedly received industrial fill of unknown quantity and type. In addition, several storm sewers and industrial outfalls from neighboring facilities reportedly discharged into Pettibone Creek that flows north to south across the site. The nearest residents are located within ½ mile to the north.

III. Methodology and Data Gaps

To determine a lead clean up goal (CUG) under an occupational scenario, this assessment utilizes the methodology presented by the Technical Review Workgroup for Lead, "Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil," (December, 1996). The assessment assumes that individuals are exposed to a background (or baseline) level of lead in their homes and that their occupational exposure represents an incremental risk. The U.S. EPA has determined a blood level level which is considered acceptable (see toxicity section). An individual will accumulate blood lead through various exposures to lead (i.e. drinking water, paint chips, lead at the workplace, etc.). The lead exposure in the workplace is therefore assumed to be only one source of that individual's total lead exposure. It is assumed that exposure to drinking water and other household sources of lead create a background (or baseline) blood lead level in the population. This background level is subtracted from the acceptable maximal level to yield the maximum amount that occupational exposure to lead can safely contribute to the total blood lead level. The acceptable level of incremental exposure to lead will therefore be dependent upon the baseline blood lead level. Ideally, the baseline blood lead level would represent the blood lead level of individuals who would potentially work on site (but before they have begun to work on site) and would be specific for the geographic location of the site. A site-specific baseline blood lead level would require sampling and calculation of current blood level in the neighborhhood around the site. Measurement of background blood lead levels of women of child-bearing age in the community would be ideal. In the absence of this data, this assessment utilizes the value of 2.2 ug/dl which is recommended by the national lead workgroup and is consistent with national data for african-american women of child-bearing age (Brody et al, 1994). The national average includes women from both urban as well as rural sites and therefore the exposure to lead is expected to be quite varied.

IV. Exposure Pathways

A residential lead risk assessment focuses on the risk to young children. This is because children are especially vulnerable to lead contamination due to: their behavior patterns which tend to result in higher lead exposures than older children or adults; their tendency to absorb more lead than do adults; and, their susceptibility to the adverse effects of lead on the nervous system.

The calculation of soil CUGs for this site is being done under the assumption that the site will be used for commercial purposes only and will be of limited access to children (i.e. not used as a day care center). Therefore, this risk assessment focuses to lead risks to workers, assumed to be adults. Within this population of workers, the subpopulation most likely to be at risk from lead exposure are pregnant women. Pregnant women are identified as the sensitive subpopulation under an occupational exposure scenario because: they may tend to absorb more lead than non-pregnant women or men; and because the fetus of the pregnant woman is likely to be especially susceptible to the adverse effects of lead.

Exposure to contaminated soil can occur via incidental ingestion and dermal absorption. Dermal absorption was not considered to be an exposure pathway for this assessment since lead does not absorb well through the skin. Another possible exposure pathway for soil is via dust inhalation. This pathway is not considered to b of significnt concern and consequently is not included in the calculation of the CUG.

The CUG only addresses exposure which would occur upon utilization of the site under a light industrial/ commercial scenario. The CUG calculated in this risk evaluation has been calculated specifically for occupational use. Residential use would necessitate a lower CUG. Therefore, it is important that any remedial alternative based on the CUG in this memo ensure that the site not be put to residential use.

V. Toxicity

The toxic effects from lead form a continuum from overt symptoms to subtle biological changes. These effects involve several target organ systems with the most sensitive effects in infants and children occurring in the central nervous system. Studies have indicated that deficits in mental development can occur in children born to mothers with elevated blood lead levels. While pregnant women are not per se at risk from slightly elevated blood lead levels, they are considered a sensitive population due to the transfer of lead via blood through the umbilical cord and to the fetus. In addition, studies indicate that the fetal brain may have an increased sensitivity to lead toxicity when compared to the more mature brain. It appears that the immature endothelial cells forming the capillaries of the developing brain are less resistant to the effects of lead than are capillaries from mature brains. Therefore, it may be easier for lead both to reach the fetal brain and damage it as it is being formed.

EPA recommends that there should be no more than a 5% likelihood that a young child should have a PbB value greater than 10 ug/dL (Technical Review Workgroup for Lead, 1996). In addition, the National Research Council Committee on Measuring Lead in Critical Populations recommends in their report (1993) a target blood lead level of 10 ug/dL in the fetus. Since the population of exposed workers are assumed to include pregnant women, and because the fetus is exposed to lead levels nearly equal to those of the mother, the health criterion selected for use in this evaluation is that there should be no more than a 5% chance that the fetus of a pregnant woman should have a PbB above 10 ug/dL. This health goal is equivalent to specifying that the 95th percentile of the PbB distribution in fetuses does not exceed 10 ug/dL.

It is important to note that the choice of 10 ug/dL as the upper 95th percentile limit for the fetus not imply that exposures above this will definitely result in unacceptable health effects and levels below this are without risk. Rather, there is a graded increase in the severity of adverse effects as blood lead levels increase.

VI. Risk and Clean Up Goals (CUG)

This evaluation assumes that the site will be used for an occupational scenario and it will not be frequented by small children. Any deviation from this use will change the CUG for the site.

This assessment does not use the 1994 U.S. EPA IEUBK Model for lead in children. The IEUBK Model as it currently exists in the EPA is appropriate only for sites in which children are directly exposed to lead. It is inappropriate to use the U.S. EPA IEUBK

Model model to calculate lead levels in adults. Indeed, the U.S. EPA Technical Review Workgroup agreed that the U.S. EPA IEUBK Model for children was inappropriate for the establishment of soil CUG's based on adult exposures and have recommended a methodology for calculating risk associated with adult exposures to lead (Technical Review Workgroup for Lead, 1996).

The equation recommended by the Technical Review Workgroup for Lead (1996) predicts the blood lead level in an adult exposed to lead in an ocupational setting. It does this by adding the baseline blood lead level to the increment in blood lead which is expected as a result of occupational exposure to soil. The increment in blood lead level is estimated by multiplying the absorbed dose of lead by a biokinetic slope factor (BKSF).

$$CUG = \frac{PbB_{GM}target - PbB_0}{BKSF \times IR \times AF}$$

where:

CUG	clean up goal for soil which is risk based
Pb_{GM}target	target geometic mean blood level concentration
PbB_0	baseline blood lead level
BKSF	biokinetic slope factor
IR	ingestion rate
AF	absorption fraction

The calculated CUG is 1,400 ppm.

Variable	Units	Value Used
Pb_{GM}target	ug/dL (lead)	4.22
PbB_0	ug/dL (lead)	2.2
BKSF	ug/dL / ug/day (lead)	0.4
IR	g/day (soil)	0.03
AF	unitless	0.12

The PbB_{GM}target is calculated using the following three parameters: the targeted 95th percentile PbB of the fetus, the fetal/maternal PbB ratio and the geometric standard deviation (GSD) of the PbB distribution for the population of women of child-bearing age. The target blood lead concentration is intended to protect against the developmental effects of lead that might result from exposure of a fetus to lead in utero when a pregnant woman works on the site. This target blood lead level in the fetus is 10 ug/dL (National Research Council, 1993). The fetal/maternal PbB ratio of 0.9 was used based on the weight of evidence from studies which examined the relationship between umbilical cord PbB and maternal PbB and is recommended by the TRW.

The GSD is a measure of the inter-individual variability in PbB in a population whose members are exposed to the same environmental lead levels. While ideally, this number is determined by site specific data, assumptions can be made regarding the GSD. The NHANES III study of blood lead levels in the U.S. (Brody et al, 1994) reports the blood lead levels in the American population and GSD vales can be extrapolated from this report. The Technical review Workgroup (1996) recommends a value that falls within the range of 1.8-2.1 ug/dL. The high end of the range is extrapolated from the U.S. popluation GSD for adult women obtained from phase 1 of NHANES III which has been estimated to be within the range of 2.1-2.6 (Brody et al, 1994). In theory, one would expect GSD values measured in populations to reflect the combined effect of variability in environmental lead concentrations in addition to the inter-individual variability in activity-weighted lead exposures and lead biokinetics. Thus the GSD values extrapolated from the national NHANES III study are likely to provide the upper bound for GSD values for individuals in a community exposed to a single, or relatively homogeneous source of lead (as is assumed for this risk assessment) and therefore overestimate the inter-individual GSD which this term is intended to represent. This assessment assumes a GSD of 1.8 ug/dl as a default value for this term, reflecting the assumption that variability in blood lead levels beween members of the community is relatively small. The value of 1.8 is at the low end of the range of possible GSD values, however, and may underestimate the inter-individual variability.

The baseline PbB_0 is intended to represent the best estimate of the geometric mean PbB in adults which have not been exposed to lead-contaminated soil from the site. The national estimate of PbB_0 is based on data for the general U.S. population of african-american women of child-bearing age (Brody et al, 1994). The population around the Vacant Lot site is primarily african-american and therefore, the value of 2.2 ug/dl is used. While this data is the best available estimation of background blood level in the neighborhood, this data may not be an accurate representation of subpopulations or activity patterns present around the Vacant Lot site.

The BKSF parameter relates PbB to dietary lead uptakes. There is some controversy around this number, and the calculated BKSF is very much dependent on the assumptions used to analyze the pharmacokinetic data. In general, however, studies examining the biokinetics of lead absorption into the blood suggest a BKSF value of 0.4. In addition, a BKSF value of 0.4 was recommended by the Technical Review Workgroup (1996).

The occupational incidental soil ingestion rate is 0.05 g/day (U.S. EPA, 1993). The worker spends an average of 250 days per year at work, reducing the average occupational ingestion rate over the year to 0.03 g/day.

Limited data are available for estimating the fraction of ingested lead which is absorbed through the gastrointestinal tract in humans. Data suggest that the AF depends upon whether the individual is in a fasted state or not. In general, individuals who have fasted absorb a higher fraction of lead from the gut. The Technical Review Workgroup (1996) recommends a value of 0.2, which was used in this calculation. The absorption value of 0.2 is further modified to account for the fact that the lead absorption range reflects lead absorption from food as opposed to dirt. A relative absorption factor of 0.6 (lead from soil/lead from food) multiplied by the 0.2 absorption value yields a lead from dirt absorption value of 0.12.

Calculation of a risk-based CUG resulted in target levels of **1,400 ppm** lead in the soil.

In order for the risk at the Vacant Lot site to fall within an acceptable range, the average concentration of lead at the Vacant Lot site should approximate 1,400 ppm. In addition, it is recommended that any hot spots which are significantly higher than the 1,400 ppm be remediated even if, when averaged, they contribute to an acceptable range. The recommended remediation of hot spots stems from the uncertainty surrounding the CUG as well as the uncertainty surrounding the future behavior patterns and movements of workers on the Vacant Lot site.

VII. Risk Characterization

The calculation of a risk-based CUG for the Vacant Lot Site is based on the U.S. EPA recommendation that there should be no more than a 5% likelihood that a young child should have a PbB value greater than 10 ug/dl. The choice of a health limit of 10 ug/dL by EPA is based on a consensus among agency scientists that effects which begin to appear at this exposure level are sufficiently undesirable to warrant avoidance. In the case of an occupational scenario, children are not expected to be exposed to the site and therefore the sensitive subpopulation becomes the developing fetus and consequently pregnant women. It is assumed that the blood lead level recommended for the protection of the young child will also be protective of the developing fetus.

VIII. Uncertainty

All assessments of risk involve factors that are uncertain and vary from individual to individual. The assumptions made in this risk evaluation include exposure assumptions, as well as science policy assumptions. The assessment is only as accurate as the assumptions that go into it. In addition, the assessment aims to protect that population that is most vulnerable to the contaminant.

The following are some examples of assumptions that are surrounded by technical and science policy uncertainty:
- the fetal/maternal PbB ratio of 0.9
- the baseline PbB lead level of 2.2 ug/dL
- the BKSF value of 0.4 $\frac{\text{ug/dL}}{\text{ug/day}}$
- the lead absorption fraction of 0.12
- the target blood lead level of 4.22 ug/dL as protective of the developing fetus.

These values were chosen based on guidance from the Technical Review Workgroup and are designed to be protective. In the instance of the BKSF value, data and precedence suggest use of 0.4. The baseline blood lead level for women in the community is not known. Therefore, this assessment uses the national average of blood lead levels for african-american women of child bearing age.

In the case of the lead absorption fraction, an AF value of 0.2 was chosen. This value is intended to represent lead absorption, primarily in the presence of food. In addition, the calculation uses a relative absorption value of 60% to estimate the amount of lead which would be absorbed from dirt as opposed to food, resulting in an input AF of 0.12. If an individual were to be consistently exposed to lead-contaminated soil while in a fasted state, this AF value would likely underestimate her risk.

IX. Conclusion

A CUG of 1,400 ppm is recommended for lead in the soil of the Vacant Lot site. This CUG was calculated for a light industrial/commercial scenario and would not apply to a residential scenario. In addition, this CUG would not be protective for a day care center or school or any commercial facility that is frequented by small children.

X. References

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